U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-271 466

Flathead Lake, Flathead and Lake Counties, Montana

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Jun 77

PB 271 466

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE

REPORT

ON

FLATHEAD LAKE

FLATHEAD AND LAKE COUNTIES

MONTANA

EPA REGION VIII

WORKING PAPER NO. 792

WITH THE COOPERATION OF THE

MONTANA DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

AND THE

MONTANA NATIONAL GUARD

JUNE, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.
3. RECIPIENT'S ACCESSION NO.	PB-277 466
4. TITLE AND SUBTITLE: Report on Flathead Lake, Flathead and Lake Counties, Montana	5. REPORT DATE: Prepared June 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	8. PERFORMING ORGANIZATION REPORT NO.: Working Paper # 792
9. PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED: Final - 1975
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		08H 05C

18. DISTRIBUTION STATEMENT: Release unlimited	19. SECURITY CLASS (This Report)	21. NO. OF PAGES: 65
	20. SECURITY CLASS (This page)	22. PRICE: PC A04, MF A01

EPA Form 2220-1 (9-73)

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

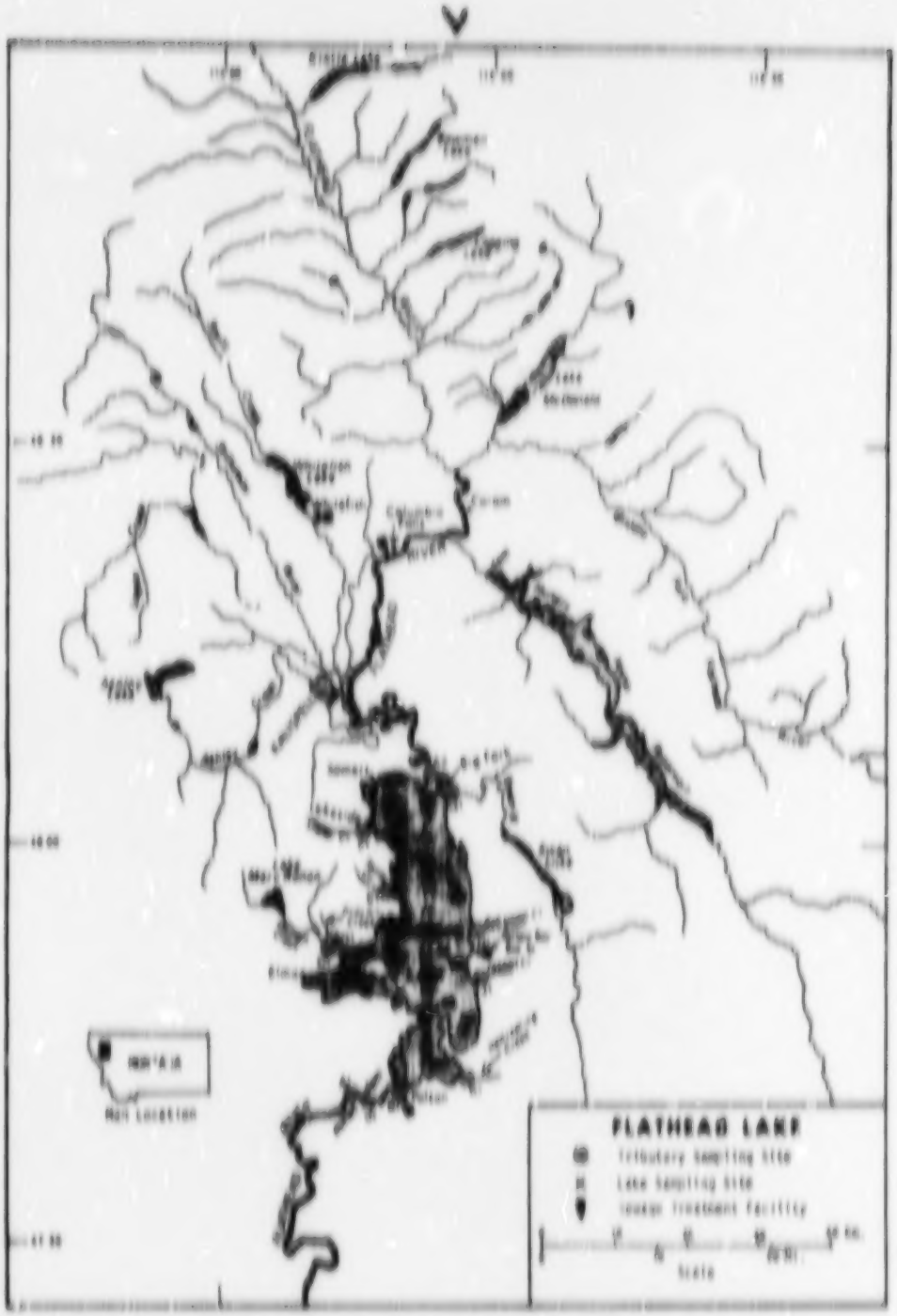
The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS
STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY


FLATHEAD LAKE
Tributary sampling site
Lake sampling site
Sewage treatment facility

FLATHEAD LAKE

STORET NO. 3003

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Flathead Lake is oligotrophic. It ranked third in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. One of the water bodies had less and one had the same median total phosphorus, two had less and three had the same median dissolved orthophosphorus, five had less and three had the same median inorganic nitrogen, one had less mean chlorophyll a, and one had greater mean Secchi disc transparency. Essentially no depression of dissolved oxygen occurred at depths as great as 68.6 meters.

In a recent limnological study (Gaufin et al., 1976), Flathead Lake was classified as oligotrophic, but the authors note that the blue-green algal blooms that have occurred in the shallower bays in recent years indicate that some parts of the lake are gradually becoming eutrophic.

B. Rate-Limiting Nutrient:

Because of significant nutrient changes in the algal assay samples during shipment from the field to the laboratory, the assay results are not considered representative of conditions in the lake at the time of sampling.

The lake data indicate nitrogen limitation in May, both nitrogen

* See Appendix A.

and phosphorus limitation in July (depending on the station), and phosphorus limitation in September.

C. Nutrient Controllability:

1. Point sources--The phosphorus contribution of known point sources, excluding Polson, amounted to 13.7% of the total load to Flathead Lake during the sampling year. The City of Kalispell added 8.8% of the total load; Bigfork, 1.4%; the Yellow Bay Biological Station, <0.1%; Whitefish, 2.2%, and Columbia Falls, 1.3% of the total. Septic tanks serving lakeshore dwellings and recreation facilities contributed an estimated 0.3% of the total, but a shoreline survey would be necessary to determine the actual significance of those sources.

Note that the Polson waste treatment facility discharges to the outlet channel and thus does not affect the trophic condition of the main body of Flathead Lake (see map, page v). Therefore, the phosphorus contributed by this source is not included in the computed areal phosphorus load to the lake; however, the Polson nutrient loads are shown in the loading tables (pages 13 and 14) since they contributed to the outlet loads measured below Kerr dam.

The present phosphorus loading of 0.36 g/m^2/year is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 16). However, the phosphorus load of the Flathead River measured during the Survey sampling year may have been somewhat less than usual. Nunnallee et al. (1975), using several years of U.S. Geological Survey and Department

of Health and Environmental Sciences phosphorus data and corresponding U.S.G.S. flows, calculated a Flathead River inlet load equivalent to 194,400 kg total phosphorus/year (including point-source loads). Including point-source loads, the comparable Survey total phosphorus load was 141,140 kg. If it is assumed that the authors' load is a more typical Flathead River load, and the difference (53,260 kg) is added to the overall Survey load, the areal loading would be increased to 0.48 $g/m^2/yr$ or a little more than an oligotrophic loading. Considering the evidence of eutrophication reported by Gaufin et al. (1976), the latter loading probably is a more typical loading than the 0.36 $g/m^2/yr$ measured during the Survey sampling year.

It should be noted that although the 53,260 kg difference in total phosphorus load appears to be substantial, because of the sizable flow of the Flathead River, a difference of less than 6 micrograms per liter mean total phosphorus concentration would account for the load difference.

2. Non-point sources--Non-point sources, including direct precipitation, accounted for 84.6% of the total phosphorus load to Flathead Lake during the sampling year. The Flathead River added 69.0% of the total; Dayton Creek, less than 0.1%; Proctor Creek, less than 0.1%; Stoner Creek, 0.1%, the Swan River, 10.2%, and the ungaged tributaries added an estimated 0.4% of the total.

The phosphorus export rates of the Flathead River, Dayton Creek,

Proctor Creek, Stoner Creek, and the Swan River were 7, <1, <1, 4, and 9 kg/km^2/year, respectively (see page 15). These export rates are quite comparable to the rates of the tributaries of other lakes in the vicinity (i.e., Mary Ronan, Swan, and Tolley lakes*).

* Respectively, Working Paper No. 796, 800, and 801.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 475.6 kilometers².
2. Mean depth: 13.5 meters.
3. Maximum depth: 110.3 meters.
4. Volume: 6,420.60 x 10⁶ m³.
5. Mean hydraulic retention time: 225 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km²)*	Mean flow (m³/sec)*
Flathead River	16,058.0	298.370
Dayton Creek	179.0	0.112
Proctor Creek	12.1	0.007
Stoner Creek	58.6	0.338
Swan River	1,080.1	32.880
Minor tributaries & immediate drainage -	182.9	0.023
Totals	18,370.6	331.730

2. Outlet -

Flathead River	18,854.2**	329.690

C. Precipitation***:

1. Year of sampling: 51.4 centimeters.
2. Mean annual: 59.0 centimeters.

† Table of metric conversions--Appendix B.
†† Tibbs et al., 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Flathead Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at ten stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled at the ten stations were 38.4, 5.2, 61.0, 53.3, 34.7, 58.[illegible], 68.6, 66.8, 39.9, and 25.9 meters, respectively.

The sampling results are presented in full in Appendix B and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR FLATHEAD LAKE
STORET CODE 3003

PARAMETER	1ST SAMPLING ([illegible]) RANGE	MEAN	MEDIAN	2ND SAMPLING ([illegible]) RANGE	MEAN	MEDIAN	3RD SAMPLING ([illegible]) RANGE	MEAN	MEDIAN
	[illegible] SITES			[illegible] SITES			[illegible] SITES		
TEMP (C)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DISS OXY (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CNDCTVY (MCROMO)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PH (STAND UNITS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOT ALK (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOT P (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ORTHO P (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NO2+NO3 (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AMMONIA (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
KJEL N (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
INORG N (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL N (MG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHLRPYL A (UG/L)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SECCHI (METERS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/29/75	1. Asterionella sp.	67
	2. Tabellaria sp.	38
	3. Dinobryon sp.	29
	4. Cryptomonas sp.	10
	5. Chroomonas sp.	10
	Total	154
07/25/75	1. Dinobryon sp.	300
	2. Centric diatoms	128
	3. Tabellaria sp.	43
	4. Asterionella sp.	43
	5. Oocystis sp.	43
	Total	667
09/08/75	1. Centric diatoms	37
	2. Chroomonas sp.	37
	3. Nitzschia sp.	37
	Total	111

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
06/29/75	1	1.1
	2	1.1
	3	1.1
	4	1.3
	5	1.0
	6	1.0
	7	1.0
	8	1.0
	9	1.1
	10	1.0

Sampling Date	Station Number	Chlorophyll a (ug/l)
07/25/75	1	0.8
	2	2.1
	3	2.4
	4	1.2
	5	1.8
	6	1.3
	7	1.3
	8	1.2
	9	1.7
	10	1.4
09/08/75	1	1.1
	2	1.2
	3	1.5
	4	1.1
	5	1.2
	6	1.2
	7	1.1
	8	1.1
	9	1.2
	10	1.6

C. Limiting Nutrient Study:

Because of significant nutrient changes in the samples during shipment from the field to the laboratory, the algal assay results are not considered representative of conditions in Flathead Lake at the times the samples were taken (05/29/75 and 09/08/75).

The lake data indicate nitrogen limitation at all stations in May, nitrogen limitation at seven of the ten stations in July, and phosphorus limitation at all stations in September.

Following is a tabulation of the mean inorganic nitrogen/orthophosphorus ratios for each of the stations and sampling

times with the indicated limiting nutrient in parentheses.

Station	06/29/75	07/25/75	09/08/75
1	4/1 (N)	15/1 (P)	20/1 (P)
2	3/1 (N)	10/1 (N)	20/1 (P)
3	4/1 (N)	16/1 (P)	26/1 (P)
4	5/1 (N)	10/1 (P)	25/1 (P)
5	4/1 (N)	4/1 (N)	27/1 (P)
6	5/1 (N)	7/1 (N)	25/1 (P)
7	6/1 (N)	6/1 (N)	25/1 (P)
8	6/1 (N)	6/1 (N)	24/1 (P)
9	6/1 (N)	9/1 (N)	24/1 (P)
10	9/1 (N)	7/1 (N)	26/1 (P)

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v). Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using annual mean concentrations and flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations C-1, D-1, F-1, and G-1 and multiplying the means by the ZZ area in km^2.

The operators of the Kalispell, Polson*, and Big Fork wastewater treatment plants provided monthly effluent samples and corresponding flow data. The cities of Whitefish and Columbia Falls did not participate; nutrient loads from these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

* The Polson treatment facility discharges to the outlet channel and thus does not affect the trophic condition of the main body of the lake (see map, page v). However, the nutrient loads from this source are shown in the following loading tables since they contributed to the outlet loads measured below Kerr dam.

The Yellow Bay Biological Station also did not participate; phosphorus loads from this source were calculated using data provided by Norpested (1977). Nitrogen loads were estimated at 3.401 kg/capita/year.

A. Waste Sources*:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Kalispell	10,500	oxid. towers & sand filters	5,416.0	Ashley Creek
Polson	2,500	stab. pond	1,041.7	Flathead River outlet
Big Fork	500	tr. filter	787.8	Flathead Lake
Yellow Bay Biol. Station	125**	P-removal	132.5	Flathead Lake
Whitefish	3,400	stab. pond	1,286.9	Whitefish River
Columbia Falls	2,000	aerated pond	757.0	Flathead River

2. Known industrial - None of nutrient significance.

* Treatment plant questionnaires; Anonymous, 1971; Munnalles et al., 1976.
** Population equivalent based on occupancy of 12 persons for eight months and 350 persons for four summer months.

B. Annual Total Phosphorus Loading - Sampling Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Flathead River	114,745	69.0
Dayton Creek	110	<0.1
Proctor Creek	5	<0.1
Stoner Creek	436	0.1
Swan River	17,625	10.2
b. Minor tributaries & immediate drainage (non-point load) -	655	0.4
c. Known municipal STP's -		
Kalispell	15,270	8.8
Polson	2,495	1.4
Big Fork	2,400	1.4
Yellow Bay Biol. Stat.	<5	<0.1
Whitefish	3,855	2.2
Columbia Falls	2,270	1.3
d. Septic tanks* -	465	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	8,325	4.8
Total	173,455	100.0

2. Outputs -

Lake outlet - Flathead River 114,370

3. Net annual P accumulation - 59,085 kg.

* Estimate based on 1,600 lakeshore dwellings, six campgrounds, and two picnic areas; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Sampling Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Flathead River	5,414,830	85.3
Dayton Creek	2,785	<0.1
Proctor Creek	195	<0.1
Stoner Creek	6,800	0.1
Swan River	387,800	6.1
b. Minor tributaries & immediate drainage (non-point load) -	16,140	0.3
c. Known municipal STP's -		
Kalispell	43,075	0.7
Polson	5,085	0.1
Big Fork	5,870	0.1
Yellow Bay Biol. Stat.	425	<0.1
Whitefish	11,565	0.2
Columbia Falls	6,800	0.1
d. Septic tanks* -	17,540	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	513,460	8.1
Total	6,347,220	100.0

2. Outputs -

Lake outlet - Flathead River 5,510,465

3. Net annual N accumulation - 836,755 kg.

* Estimate based on 1,600 lakeshore dwellings, six campgrounds, and two picnic areas; see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Flathead River	7	341
Dayton Creek	<1	16
Proctor Creek	<1	16
Stoner Creek	4	116
Swan River	9	205

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Bohannon Creek	0.013	0.399
Forrey Creek	0.016	0.689
Teepee Creek	0.019	0.394
Hellroaring Creek	0.014	0.377

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.36	0.12	13.3	1.8

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Flathead Lake:

"Dangerous" (eutrophic loading)	0.90
"Permissible" (oligotrophic loading)	0.45

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN REMARKS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SUB- [illegible] SUR SIC	[illegible] CHLOR	15- [illegible]	[illegible] DISS INORG P
3301	CANYON FERRY RESERVOIR	0.047	0.171	442.451	5.816	14.451	0.029
3302	CLARK CANYON RESERVOIR	0.044	0.160	348.750	2.375	12.037	0.027
3303	FLATHEAD LAKE	0.004	0.158	267.833	1.273	9.888	0.004
3304	HUNGRY HORSE RESERVOIR	0.022	0.040	367.333	0.983	18.288	0.011
3305	KOOCANUSA RESERVOIR	0.022	0.046	357.788	4.011	13.611	0.029
3306	LIBBY RESERVOIR	0.045	0.156	337.643	2.669	18.481	0.044
3307	MARY RONAN LAKE	0.023	0.040	371.841	4.673	14.286	0.006
3308	MC DONALD LAKE	0.036	0.146	198.667	9.467	9.438	0.002
3309	NELSON RESERVOIR	0.029	0.075	456.750	7.233	11.463	0.007
3310	SEELEY LAKE	0.015	0.040	362.857	2.171	13.291	0.018
3311	SWAN LAKE	0.010	0.059	282.750	3.299	9.838	0.004
3312	TALLY LAKE	0.011	0.059	334.167	2.063	9.238	0.004
3313	TIGER RESERVOIR	0.016	0.108	446.555	2.004	9.603	0.004
3314	TONGUE RIVER RESERVOIR	0.051	0.058	474.111	14.678	13.688	0.008
3315	WHITEFISH LAKE (LOWER)	0.003	0.046	248.000	1.403	7.048	0.003

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3001	CANYON FERRY RESERVOIR	14 (2)	14 (2)	21 (3)	21 (3)	0 (0)	7 (1)	77
3002	CLARK CANYON RESERVOIR	7 (1)	21 (3)	29 (4)	64 (9)	36 (5)	14 (2)	171
3003	FLATHEAD LAKE	89 (12)	61 (8)	93 (13)	93 (13)	86 (12)	75 (9)	497
3004	GEORGETOWN RESERVOIR	36 (5)	79 (10)	58 (7)	14 (2)	57 (8)	25 (4)	268
3005	HEBGEN RESERVOIR	39 (5)	79 (10)	43 (6)	36 (5)	14 (2)	21 (3)	232
3006	KOOCANUSA RESERVOIR	21 (3)	29 (4)	71 (10)	57 (8)	50 (7)	0 (0)	228
3007	MARY RONAN LAKE	58 (7)	96 (13)	36 ([illegible])	29 (4)	7 (1)	57 (8)	275
3008	MC DONALD LAKE	100 (14)	4 (0)	100 (14)	100 (14)	100 (14)	100 (14)	504
3009	NELSON RESERVOIR	29 (4)	36 (5)	7 (1)	7 (1)	43 (6)	50 (7)	172
3010	SEELEY LAKE	64 (9)	96 (13)	57 (8)	71 (10)	29 (4)	36 (5)	353
3011	SWAN LAKE	79 (11)	46 (6)	86 (12)	43 (6)	68 (9)	75 (9)	397
3012	TALLY LAKE	71 (10)	61 (8)	64 (9)	79 (11)	79 (11)	75 (9)	429
3013	TIBER RESERVOIR	57 (8)	4 (0)	14 (2)	50 (7)	68 (9)	75 (9)	268
3014	TONGUE RIVER RESERVOIR	0 (0)	46 (6)	0 (0)	0 (0)	21 (3)	43 (6)	110
3016	WHITEFISH LAKE (LOWER)	89 (12)	79 (10)	79 (11)	86 (12)	93 (13)	93 (13)	526

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3026	[illegible] LAKE (LOWER)	519
2	3004	MC DONALD LAKE	504
3	3003	FLATHEAD LAKE	497
4	3012	TAL..Y LAKE	429
5	3011	SWAN LAKE	347
6	3010	SEELEY LAKE	353
7	3007	[illegible]	275
8	3013	[illegible]	268
9	3004	[illegible]	268
10	3005	[illegible]	232
11	3006	[illegible]	229
12	3014	[illegible]	172
13	3002	CLARK CANYON RESERVOIR	171
14	3019	TONGUE RIVER RESERVOIR	110
15	3001	[illegible]	77

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MONTANA [illegible]

LAKE CODE [illegible] FLATHEAD LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) [illegible]

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
[illegible]	[illegible]	147.24	145.71	154.42	254.76	736.24	1009.00	521.1	196.35	154.04	162.42	145.17	144.26	329.49
[illegible]	[illegible]	138.75	121.74	178.26	344.44	406.14	453.00	355.44	116.04	113.27	133.04	135.42	147.25	248.37
[illegible]	174.0	0.071	0.071	0.085	0.170	0.425	0.276	0.113	0.057	0.028	0.028	0.057	0.071	0.117
[illegible]	12.3	0.0	0.0	0.099	0.028	0.085	0.804	0.085	0.0	0.0	0.0	0.0	0.0	0.087
[illegible]	56.5	0.113	0.113	0.142	0.283	0.963	1.494	0.425	0.113	0.057	0.142	0.142	0.142	0.338
[illegible]	[illegible]	14.16	13.76	17.57	43.89	86.45	93.46	45.31	24.92	15.57	15.86	15.86	15.57	32.48
[illegible]	147.4	0.0	0.0	0.014	0.057	0.113	0.057	0.028	0.0	0.0	0.0	0.0	0.0	0.023

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = [illegible] TOTAL FLOW IN = [illegible]

SUM OF SUB-DRAINAGE AREAS = [illegible] TOTAL FLOW OUT = [illegible]

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[illegible]	10	74	214.500	5	215.249				
	11	74	305.824	3	311.445				
	12	74	314.307	7	331.307				
	1	75	237.074	4	236.179				
	2	75	256.221						
	3	75	207.214	8	205.411		[illegible]		
	4	75	175.869	7	184.600				
	5	75	334.226						
	6	75	1020.036	7	920.469				
	7	75	507.489	15	652.207				
	8	75	259.423	13	98.114				
	9	75	207.593	6	713.091				
[illegible]	10	74	213.202	5	344.609				
	11	74	296.830	2	300.745				
	12	74	148.724	7	198.695				
	1	75	128.728	5	116.923				
	2	75	45.319	1	0.0				
	3	75	105.707	15	130.753				
	4	75	131.798	5	150.441				
	5	75	534.694	3	135.401				
	6	75	1040.764	7	1037.424				
	7	75	504.507						
	8	75	175.786	13	141.584				
	9	75	146.207	4	173.264				

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TRIBUTARY FLOW INFORMATION FOR MONTANA 10/05/76

LAKE CODE 3007 FLATHEAD LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3007C1	10	74	0.074	5	0.074				
	11	74	0.057						
	12	74	0.057	7	0.057				
	1	75	0.057	4	0.057				
	2	75	0.057						
	3	75	0.057	8	[illegible]	15	0.057		
	4	75	0.113	7	0.142				
	5	75	0.340	4	0.510				
	6	75	0.198	7	0.283				
	7	75	0.142	15	0.142				
	8	75	0.071	13	0.085				
	9	75	0.028	8	0.028				
3007F1	10	74	0.0	5	0.0				
	11	74	0.0	3	0.0				
	12	74	0.0	7	0.0				
	1	75	0.0	4	0.0				
	2	75	0.0						
	3	75	0.006	8	0.0	15	0.006		
	4	75	0.017	7	0.017				
	5	75	0.017	4	0.034				
	6	75	0.008	7	0.006				
	7	75	0.003						
	8	75	0.0	13	0.0				
	9	75	0.0	8	0.0				
[illegible]	10	74	0.156	5	0.156				
	11	74	0.170	3	0.170				
	12	74	0.170	7	0.170				
	1	75	0.127	4	0.142				
	2	75	0.127						
	3	75	0.142	8	0.113	15	0.142		
	4	75	0.227	7	0.142				
	5	75	[illegible]						
	6	75	[illegible]	4	[illegible]	8	0.708		
	7	75	0.566	15	0.425				
	8	75	0.170	13	0.142				
	9	75	0.071	8	0.057				
3007G1	10	74	[illegible]	5	[illegible]				
	11	74	[illegible]	2	12.742				
	12	74	[illegible]	7	12.176				
	1	75	[illegible]	5	[illegible]				
	2	75	[illegible]	1	[illegible]				
	3	75	12.176	15	[illegible]				
	4	75	[illegible]	5	[illegible]				
	5	75	[illegible]						
	6	75	[illegible]	7	[illegible]				
	7	75	[illegible]						
	8	75	[illegible]	13	[illegible]				
	9	75	[illegible]	8	[illegible]				

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

STORET RETRIEVAL DATE 76/06/05

380303
47 47 28.0 114 04 38.0 3
FLATHEAD LAKE
30047 MONTANA
130291

11EPALES 2111202
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/24	10 35	0000	5.4	11.6	470	114	8.20	42	0.020K	0.300	0.020	0.014K
	10 35	0005	5.4	11.8		116	8.25	46	0.020	0.200K	0.040	0.014K
	10 35	0025	4.4	11.8		113	8.25	46	0.020	0.200K	0.030	0.017K
	10 35	0100	4.1	11.6		109	8.25	43	0.075	0.200K	0.030	0.014K
	10 35	0150	4.0	11.6		109	8.10	41	0.020K	0.210K	0.030	0.010K
	10 35	0200	3.5	11.6		105	8.10	42	0.020	0.210K	0.036	0.014K
75/07/25	15 00	0000	20.2	9.2	40	150	8.40	47	0.025	0.500	0.020	0.002
	15 00	0005	21.4	9.0		151	8.45	46	0.020K	0.400	0.020K	0.002K
	15 00	0010	21.3	9.6		150	8.45	47	0.020K	0.400	0.020K	0.002K
	15 00	0020	20.7	9.6		135	8.30	47	0.020K	0.250K	0.070	0.002K
	15 00	0050	16.3	10.0		117	8.20	42	0.020K	0.200K	0.040	0.002K
	15 00	0100	13.3	11.2		110	8.25	41	0.020K	0.200K	0.056	0.003
	15 00	0111	11.6	10.4		110	8.10	42	0.020	0.200K	0.056	0.004
	15 00	0150	11.7	10.0		109	8.20	41	0.020	0.200K	0.052	0.003
75/09/08	15 10	0000	17.1	9.4	340	130	8.35	[illegible]	0.020K	0.200K	0.020K	0.002K
	15 10	0005	16.9	9.6		130	8.30	46	0.020K	0.200K	0.020K	0.002K
	15 10	0020	16.5	9.2		136	8.30	46	0.020K	0.200K	0.020K	0.002K
	15 10	0040	15.4	9.0		134	8.30	47	0.020K	0.200K	0.020K	0.002K
	15 10	0065	9.6	9.2		110	8.10	43	0.020K	0.200K	0.030	0.002K
	15 10	0100	7.6	10.0		115	8.00	41	0.020K	0.200K	0.040	0.002K
	15 10	0140	6.1	10.2		110	8.00	41	0.020K	0.200K	0.056	0.002K
	15 10	0175	5.4	10.0		109	8.20	42	0.020K	0.200K	0.052	0.002K

K VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible] GEOLOGICAL SURVEY [illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible] FEET [illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.1	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	2.4	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	1.5	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		

[illegible]

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			[illegible]	[illegible]
TO	[illegible]	FEET	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		

[illegible]

[redacted]

[redacted]

[redacted]

STORET RETRIEVAL DATE 77/08/15

300567
47 51 48.0 114 03 58.0 3
FLATHEAD LAKE
30047 MONTANA
130291

11EPALES 2111202
0164 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3+NH4- N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/29	15 15	0000	7.4	11.4	480	115	8.20	107	0.020	0.200K	0.030	0.010K
	15 15	0005	5.2	12.0		114	8.25	98	0.030	0.200K	0.030	0.013K
	15 15	0025	4.3	11.8		105	8.25	98	0.020	0.200K	0.020	0.012
	15 15	0040	4.0	11.6		107	8.30	96	0.030	0.200K	0.030	[illegible]
	15 15	0100	4.0	12.0		107	8.30	97	0.030	0.200K	0.040	[illegible]
	15 15	0150	3.7	11.6		106	8.25	98	0.030	0.200K	0.040	[illegible]
	15 15	0200	3.7	11.6		109	8.25	91	0.030	0.200K	0.030	[illegible]
75/07/25	11 00	0000	20.4	9.0	96	160	8.50	88	0.025	0.200	0.020	[illegible]
	11 00	0005	20.3	9.4		150	8.50	93	0.020	0.200K	0.020K	[illegible]
	11 00	0020	20.0	11.2		140	8.10	94	0.020	0.200	0.040	[illegible]
	11 00	0050	10.5	10.3		120	8.05	95	0.025	0.200K	0.010	[illegible]
	11 00	0100	10.0	11.4		114	8.00	99	0.030	0.200K	0.040	[illegible]
	11 00	0150	6.2			116	8.10	98	0.021	0.200K	0.040	[illegible]
	11 00	0225	7.4	11.6		118	8.05	92	0.020	0.200K	0.040	[illegible]
75/09/09	11 50	0000	17.1	9.4	312	139	8.20	93	0.020K	0.250K	0.020K	0.002K
	11 50	0005	16.4	9.4		137	8.30	93	0.020K	0.200K	0.020K	0.002K
	11 50	0020	16.4	9.4		136	8.35	95	0.020K	0.200K	0.020K	0.002K
	11 50	0050	13.4	9.4		130	8.20	95	0.020K	0.200K	0.020K	0.002K
	11 50	0085	8.5	9.6		118	8.00	96	0.020K	0.200K	0.050	0.002K
	11 50	0135	6.4	10.8		112	7.95	92	0.020K	0.200K	0.040	0.002K
	11 50	0175	5.6			118	8.00	94	0.020K	0.200K	0.050	0.002K

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/05

390326
47 57 36.0 114 03 57.0 3
FLATHEAD LAKE
30047 MONTANA
130294

11EPALES 2111202
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/24	16 15	0000	6.3	11.2	196	122	8.45	46	0.030	0.200	0.030	0.005J
	16 15	0005	6.5	11.6		116	8.35	47	0.020	0.200K	0.030	0.010K
	16 15	0025	[illegible]	11.6		109	8.35	46	0.030	0.200K	0.030	0.005
	16 15	0060	6.6	11.6		107	8.25	48	0.040	0.200K	0.040	0.010J
	16 15	0100	6.3	11.6		107	8.20	51	0.020	0.200K	0.030	0.010K
	16 16	0150	6.2	11.9		107	8.20	48	0.040	0.200K	0.040	0.010K
	16 15	0200	3.6	11.2		107	8.20	46	0.040	0.200K	0.030	0.010K
75/07/25	10 25	0000	24.6	10.6	150	160	8.50	60	0.020	0.400	0.020K	0.010K
	10 25	0005	24.6	9.2		159	8.50	60	0.020K	0.200	0.020K	0.010K
	10 25	0025	23.5	10.2		143	8.20	48	0.020	0.200	0.040	0.010K
	10 25	0050	12.3	9.2		120	8.20	47	0.020	0.200K	0.040	0.006
	10 25	0100	9.5	10.0		110	8.20	43	0.020	0.200K	0.040	0.002
	10 25	0150	7.1	9.8		110	8.15	46	0.030	0.200K	0.040	0.017
	10 25	0219	7.1	10.6		105	8.20	46	0.020	0.200K	0.070	0.012
75/09/24	11 00	0000	16.4	9.6	300	139	8.25	43	0.020K	0.200K	0.020K	0.002K
	11 00	0005	16.0	9.6		139	8.30	43	0.020K	0.200K	0.020K	0.002K
	11 00	0020	16.4			136	8.35	44	0.020K	0.200K	0.020K	0.002K
	11 00	0042	15.6	9.2		132	8.30	44	0.020K	0.200K	0.020K	0.002K
	11 00	0060	9.7	9.6		120	8.05	47	0.020K	0.200K	0.020	0.002K
	11 00	0095	7.6			114	7.90	46	0.020K	0.200K	0.040	0.002K
	11 00	0135	6.2	10.6		111	7.95	44	0.020K	0.200K	0.040	0.002K
	11 00	0175	5.6	10.6		104	8.00	46	0.020K	0.200K	0.040	0.002K

K* VALUE KNOWN TO BE LESS THAN INDICATED

J* VALUE [illegible]

STORET RETRIEVAL DATE 79/08/05

3803?4
47 57 54.0 114 03 57.0 3
FLATHEAD LAKE
30047 MONTANA
130241

11EPALES 2111202
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/29	16 15	0000	0.009	1.2	
	16 15	0005	0.007		
	16 15	0075	0.010		
	16 15	0060	0.012		
	16 15	0100	0.006		
	16 15	0150	0.006		
	16 15	0200	0.005		
75/07/25	10 25	0000	0.007	1.2	
	10 25	0005	0.004		
	10 25	0025	0.010		
	10 25	0050	0.009		
	10 25	0100	0.007		
	10 25	0200	0.021		
	10 25	0214	0.030		
75/09/04	11 00	000C	0.004	1.1	
	11 00	0005	0.006		
	11 00	0025	0.007		
	11 00	0042	0.007		
	11 00	0060	0.006		
	11 00	0095	0.007		
	11 00	0135	0.007		
	11 00	0175	0.006		

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APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/08/05

380341
47 41 48.0 114 14 15.0 4
FLATHEAD RIVER
30 7.5 POLSON
UPFLATHEAD LAKE 130241
[illegible] AT END OF ROAD .2 MI BELOW KERR DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3+NH4- N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	11 10		0.012	0.250	0.005	0.005K	0.010K
74/11/03	10 00		0.004	1.500	0.025	0.005K	0.010K
74/12/07	10 30		0.014	0.400	0.010	0.005K	0.010K
75/01/04	12 30		0.040	0.200	0.000	0.010	0.010
75/02/04	15 30			0.400	0.040	0.004K	0.010K
75/03/14	11 07		0.010	0.300	0.014	0.004K	0.010K
75/04/07	10 45		0.022	0.250	0.020	0.005K	0.010
75/06/07	11 00		0.030	1.250	0.015	0.005K	
75/07/15	10 35		0.029	0.250	0.010	0.005K	0.010
75/08/13	11 00		0.110	0.550	0.020	0.015	0.030
75/09/04	14 10		0.013	0.450	0.007	0.005	0.010

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LESS THAN INDICATED

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DATE	TIME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	13	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	11	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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TRIP	OF		[illegible]	%	TOTAL	[illegible]	
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible] %	[illegible] %
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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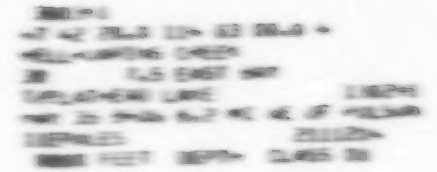

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STORET RETRIEVAL DATE 76/08/25

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48 12 ??.? 114 ?? ??.? ?
KALISPELL
30029 7.5 KALISPELL
FLATHEAD LAKE 130291
ASHLEY CREEK TO FLATHEAD RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/01/27	08 00								
CP(T)-			0.090	26.000			9.000	1.400	1.400
75/01/27	17 00								
75/02/25	09 00								
CP(T)-			0.050	19.000	1.250	4.400	6.250	1.400	1.400
75/02/25	16 00								
75/03/24	09 00								
CP(T)-			0.090	16.500	4.770	5.400	6.000	1.500	1.400
75/03/24	16 00								
75/04/10	09 00								
CP(T)-			0.050	20.000	7.750	7.300	7.400	1.500	1.500
75/04/11	16 00								
75/05/20	09 00								
CP(T)-			0.050	17.000	3.700	5.400	5.400	1.400	1.500
75/05/20	15 00								
75/06/19	00 00								
CP(T)-			0.050	19.500	4.420	5.400	4.700	1.300	1.500
75/06/19	00 00								
75/07/14	08 00								
CP(T)-			0.025	21.000	7.600	6.100	7.800	1.300	1.300
75/07/14	24 00								
75/08/21	08 00								
CP(T)-			0.075	23.000	7.090	6.700	5.100	1.200	1.300
75/08/21	24 00								
75/09/21	09 00								
CP(T)-			0.050	25.700	9.400	7.200	8.400	1.500	1.500
75/09/21	09 00								
75/10/30	08 00								
CP(T)-			0.025	24.000	4.400	7.300	7.400	1.200	1.200
75/10/30	24 00								
75/11/21	08 00								
CP(T)-			0.025	31.000	13.500	6.300	6.100	1.500	1.400
75/11/21	24 00								
75/12/15	14 00		0.025	24.000	4.400	7.500	4.000	1.300	1.300
76/01/14	09 00								
CP(T)-			0.075	17.000	4.300	4.700	5.000	1.250	1.300
76/01/14	20 00								

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